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NRL Report 6117

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Temperature and Spectral Profile of Full-Scale Propellant Grains

[UNCLASSIFIED TITLE]

G. L. Knestrick

Radiometry Branch
Optics Division

July 22, 1964

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PREVIOUS REPORT ON THIS STUDY

"Color Temperature and Spectral Profile of Some Propellant Grains," F. D. Harrington and G. L. Knestrick, NRL Report 6066 (Confidential Report, Unclassified Title), March 1964

CONTENTS

ABSTRACT
[Confidential]

Four types of observations were made of the radiant energy from Polaris second-stage propellant plumes at the Allegany Ballistics Laboratory. Observations were made of radiant emittance vs time, spectral radiance vs time, time-integrated spectral radiance, and visible light modulation of the flame. The flame spectrum was predominantly a continuum on which were superimposed weak lines of aluminum and sodium and weak bands of AlO. No spectral absorption zones were noted between 3600 and 6800A. Spectral distribution, or "color," temperatures derived from spectral radiances measured for four range tests indicate an average burning temperature of 2430°K.

PROBLEM STATUS

This is an interim report on one phase of the problem; work is continuing on this and other phases.

AUTHORIZATION

NRL Problem A02-17
Project RR 004-02-42-5152

Manuscript submitted May 4, 1964.

TEMPERATURE AND SPECTRAL PROFILE OF FULL-SCALE PROPELLANT GRAINS
[Unclassified Title]

INTRODUCTION

This is the second report on a series of spectral measurements being made on the plumes emitted by solid-propellant rocket motors. The previous report (1) dealt with initial measurements of the "color temperature"* and spectral profile of scaled-down propellant grains burning at a simulated high altitude. This report presents similar data for full-scale, second-stage Polaris motors burning at essentially sea level pressure. The present data will ultimately be compared with data to be taken on scaled-down grains burned at sea level with the object of helping to determine the adequacy of scaled-down tests for the prediction of the spectral characteristics of full-scale rocket plumes.

The current observations were on full-scale motors fired on test stands at the Allegany Ballistics Laboratory near Cumberland, Md. Spectrographic and thermal radiation monitoring devices were housed in a trailer located 75 ft away from the test stand.

INSTRUMENTATION

The streak spectrograph used in this study covered the spectral range from 3600 to 6800A with a time resolution which could be varied from 0.10 to 3.8 msec. The entrance aperture was a pinhole of 0.007-in. diameter; the lenses were quartz and lithium fluoride, and the prisms were quartz. The data obtained with the streak spectrograph were recorded on 75-mm film.

The f/10 Hilger medium-glass spectrograph used in this study had glass optical elements and a variable width slit and produced on the plate a 14-cm-wide spectrum which covered the range from 3600 to 6800A, the instrumental limits.

The radiance of a portion of the plume was monitored with an Eppley circular thermopile and recorded as a voltage on a Sanborn recorder. The thermopile had a calcium fluoride window and a time constant of approximately 6 sec. A quartz lens was used to form an image of a portion of the plume on the receiver, and, thereby, to restrict the field of view of the thermopile. The thermopile-lens-recorder system was calibrated with a tungsten secondary standard lamp which had been compared with a tungsten standard calibrated for total irradiance by the National Bureau of Standards. By calibrating the system in terms of irradiance at the lens, the error introduced by the long-wavelength cutoff of quartz was minimized. Any residual error would be due to a difference in the spectral distributions of the calibrating source and the flame. The latter, which in general is slightly hotter, would be expected to emit a lesser percentage of its energy beyond 3 to 4μ. Hence, the measured irradiance values for the flame are probably high – the error being a maximum of 8 percent if the flame is assumed to have a Planckian distribution corresponding to the highest temperature obtained from time-resolved spectra, but only 3 percent if the mean temperature obtained is used.

*The expression "color temperature" is really improperly applied to something which is more correctly described as a "blackbody spectral distribution temperature." The latter expression is so awkward that "color temperature" seems to have become the accepted jargon.

A modified General Radio high-speed streak camera was used for two firings to monitor the total light output of several small areas of the flame. These small areas were defined by a row of nine holes, arranged diagonally in the focal plane of the camera lens whose focal length was 6 in. The diameter of eight of the holes was 0.056 in. and that of the ninth hole was made smaller (0.012 in.) to serve as an index. The film speed was continuously variable and the film capacity was 100 ft of 35-mm film.

EXPERIMENTAL PROCEDURE

The arrangement of the instruments in the semitrailer is shown schematically in Fig. 1. The trailer was positioned with its back doors toward the rocket motor, and for stability the trailer was supported by blocking up the frame. The back end of the trailer was enclosed by a plywood baffle to reduce extraneous light inside the trailer. Holes were cut in the baffle only large enough to permit an unobstructed field of view for each instrument. The distance from the center of the motor nozzle plane to the baffle was 73 ft, and the angle of observation of the plume was approximately 55° to the axis of the plume. The motor was mounted on a test stand with its long axis in a horizontal position (Fig. 1).

Optical alignment of the instruments with the plume was accomplished by pointing them at a spotlight located 3 ft directly behind the rocket nozzles. This position is indicated in the sketch of the arrangement in Fig. 2, which shows the relative positions of flame and instrumentation. This area behind the rocket motor was chosen for the observations because in films of previous firings the exhaust appeared less obscured by smoke and debris in that region.*

Electrical power for remote operation of the instruments was furnished via circuits controlled by the sequence timing equipment for the rocket test range. The film drive motor of the streak spectrograph was energized at -1 sec, with one exception which will be noted later; the remotely controlled shutter of the medium spectrograph also was energized at -1 sec. The amplifier of the Sanborn recorder was operated on continuous power; only the chart drive was operated remotely, and its circuit was energized at -5 sec. Since the recording time of the high-speed camera was limited to a few seconds, its starting time was delayed until +10 sec.

Two types of optical filters were used with the streak spectrograph on separate firings. One type was a neutral-density filter consisting of a thin quartz plate on which was evaporated a platinum film. Such a filter was used (Fig. 1) to attenuate the light entering the spectrograph in order to prevent overexposure of the film. The other type of filter used was a "color-temperature correcting" filter which, by selective attenuation of the red portion of the spectrum, enabled a more uniform exposure of the entire spectrum to be obtained.

The streak spectrograph was operated with three different linear film speeds on separate firings. The speeds were 3.10 in./sec, 8.25 in./sec, and 9.75 ft/sec. The corresponding time resolutions equivalent to 1 pinhole diameter on the film were 3.8, 1.4, and 0.10 msec, respectively. When operated at the highest speed, the film drive motor was not energized until +10 sec. The film, 70-mm Kodak Tri-X Aerecon, was processed in x-ray developer at 68°F for 15 min in a Fairchild reciprocating tank.

*See, however, last paragraph in Results section, p. 11.

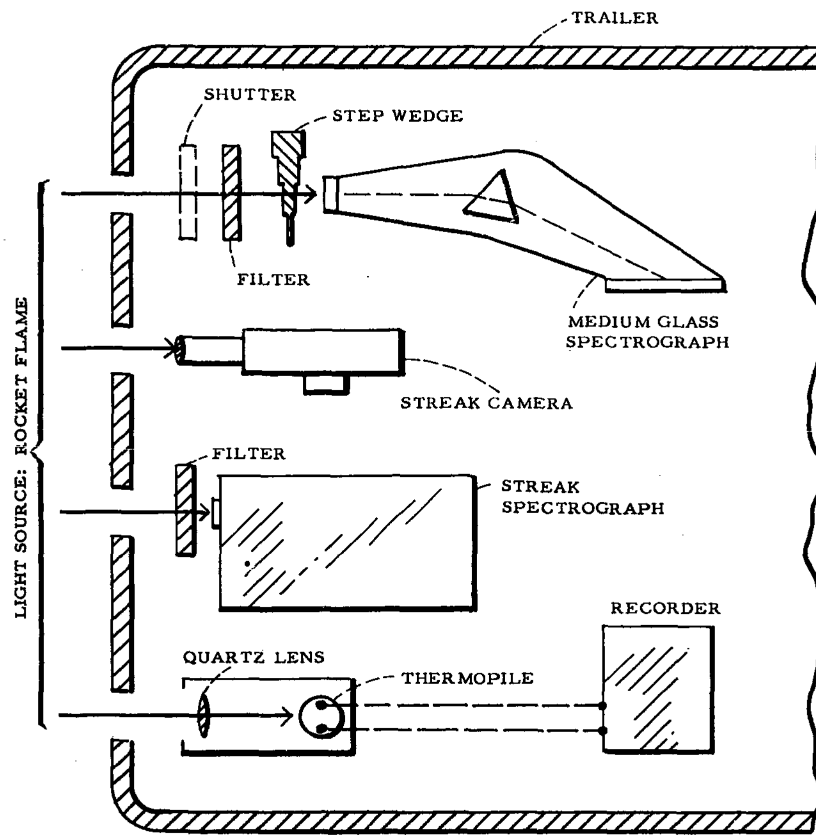


Fig. 1 - Diagram of instrumental setup used to record temperatures and spectral profiles of rocket plumes from the trailer

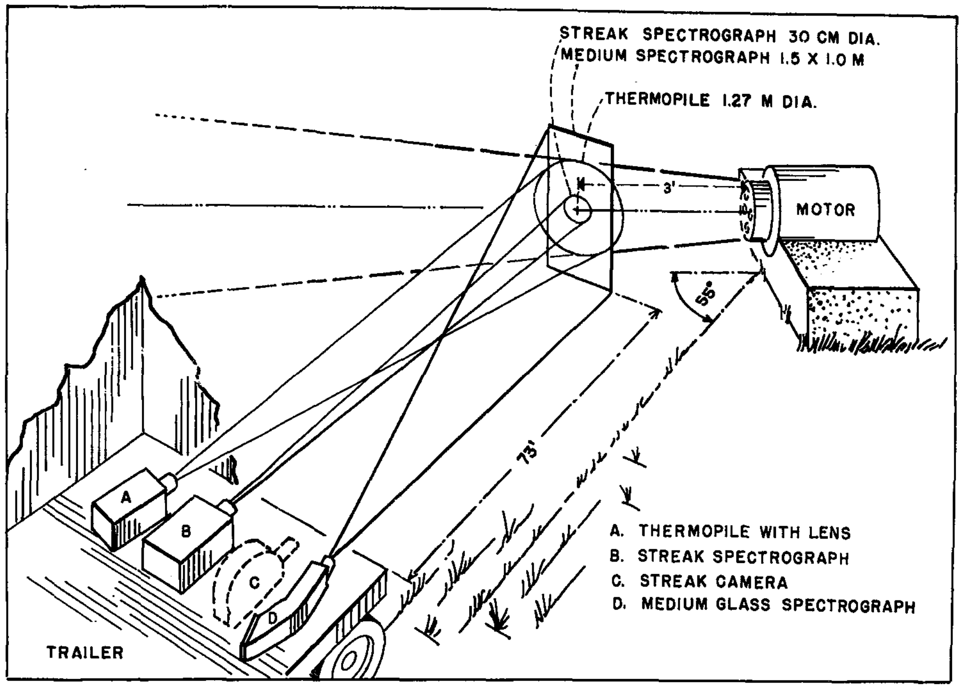


Fig. 2 - Portions of flame observed by different instruments

The field of view of this spectrograph is shown superimposed on the rocket plume in Fig. 2 and was limited to a 30-cm-diam area of flame by a 1.2-cm focal length lens in front of the pinhole aperture.

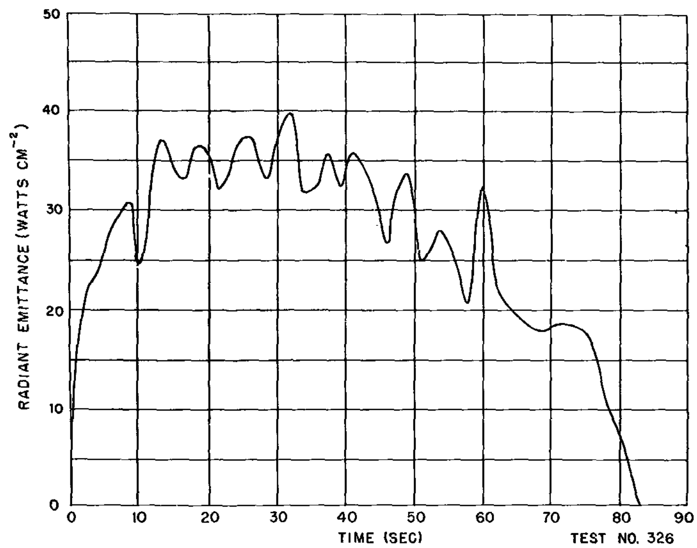
The medium-glass spectrograph had a rectangular field of view which, when projected upon the plume (Fig. 2), was larger than the plume in the vertical dimension and was one meter wide. To help prevent overexposure of the plate a step wedge (Fig. 1) was placed in front of the slit. It consisted of five steps varying in density from 0 (or clear) to 2.0 (transmission = 10^{-2}) and was of the evaporated-metal-film type. The slit width was set at 0.010 mm for the two firings on which data were obtained, namely, range tests No. 326 and No. 2062. A "color-temperature correcting" filter was used on the latter of these two firings, but not on the former. The spectra were recorded on type I-F plates which were brush-developed in Phenidone at 68°F for 5 min.

A neutral filter of 0.25 (25 percent) transmittance was used with the thermopile on the first test (range test No. 2052) only; no filter was used in this system on any subsequent test. The area of flame viewed by the thermopile-lens combination was 1.27 m in diameter (Fig. 2).

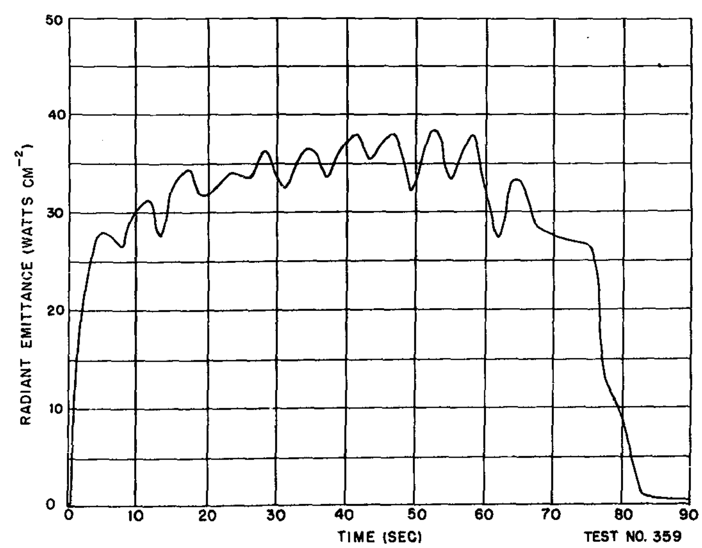
RESULTS

Thermopile Measurements of Emittance

The radiant emittance of a portion of the rocket flame as a function of time was calculated from the data obtained for each of five motor firings (Fig. 3). The thermopile

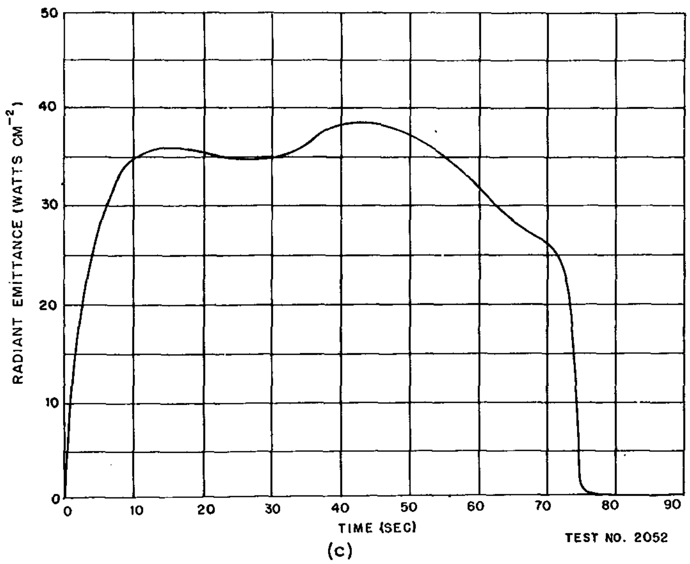


(a)



(b)

Fig. 3 - Radiant emittance vs time of 1.27-m-diam area of plume for five range tests



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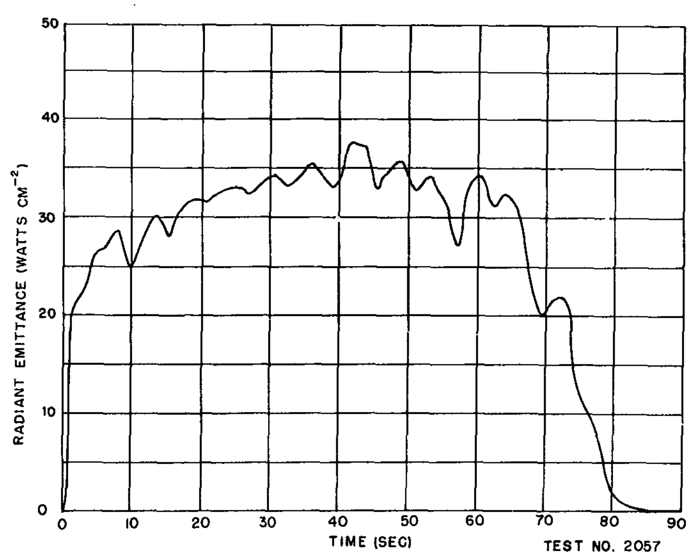
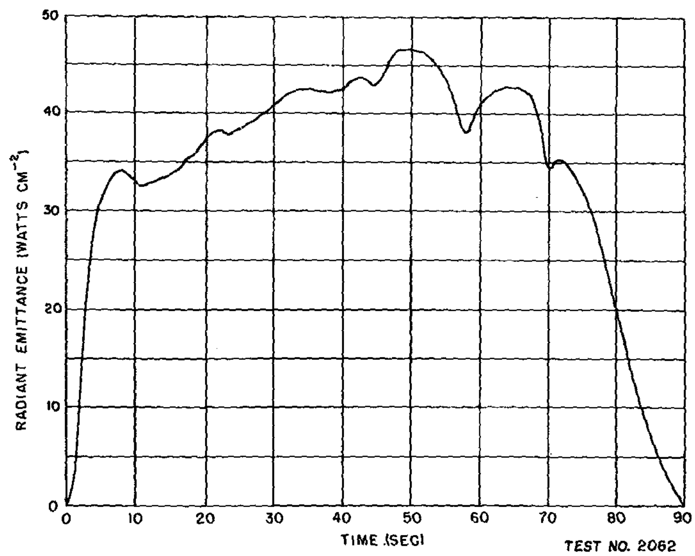


(d)

Fig. 3 (cont'd) - Radiant emittance vs time of 1.27-m-diam area of plume for five range tests



(e)

Fig. 3 (cont'd) - Radiant emittance vs time of 1.27-m-diam area of plume for five range tests

system measured the irradiance, at the trailer, from the observed area of the plume. By working back to the plume through the geometry of the system, the radiance of the observed area was then calculated. The radiation emitted by the plume was assumed to follow a Lambert cosine distribution, so the calculated radiance values were multiplied by π to obtain the radiant emittance. By assuming an emissivity of unity it was possible to convert the radiant emittance, averaged over three-quarters of the total burning time, to an average equivalent blackbody temperature for the portion of flame observed. The temperatures thus obtained, along with the measured flux values, are listed in Table 1.

Time-Resolved Spectra

The time-resolved spectra were analyzed with a Jarrell-Ash recording microphotometer. A section of the processed film (Fig. 4) from each test was scanned by this instrument both in the time dimension and spectrally. The film sections studied corresponded to the flame at a burning time of +40 sec in all cases, except the one in which the highest film speed was used. In this latter case the spectra were recorded only from +10 to +20 sec, and the spectral scan of the film was made at a film position corresponding to a burning time of +15 sec. In addition, a spectral study of the film from test No. 2057 was made at 10-sec intervals from +0.05 through +70 sec, for a total of eight spectral scans. Film density as a function of wavelength was obtained from the microphotometer trace (Fig. 5) for each scan. The density values were converted to relative exposure values through H&D curves, which were obtained with an EG&G sensitometer and with three different wavelengths of light.

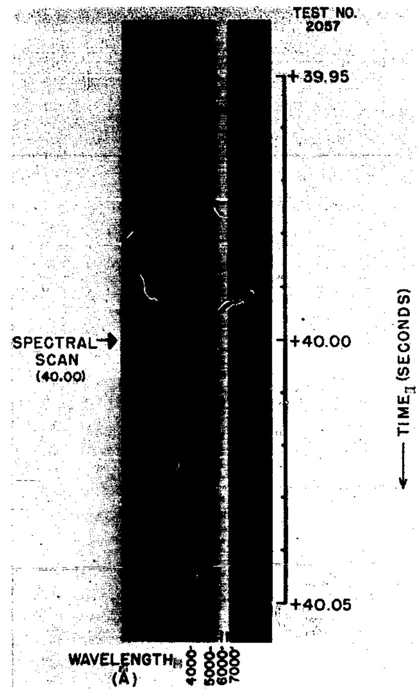


Fig. 4 - Section of time-resolved spectrum showing time location of spectral scan made with microphotometer for range test No. 2057

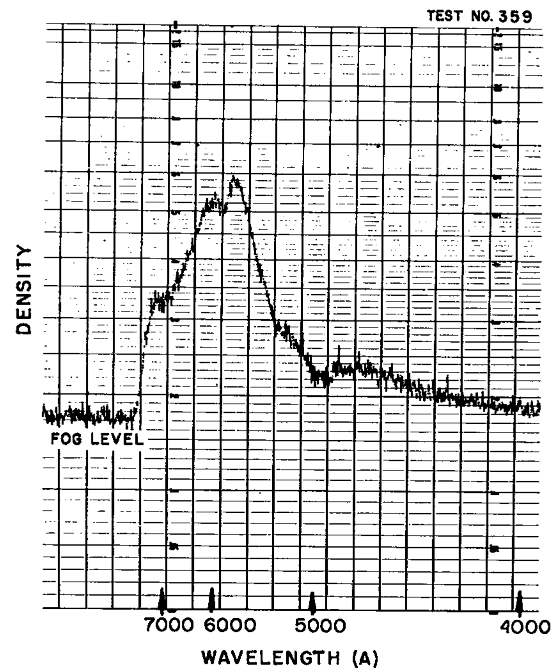


Fig. 5 - Microphotometer trace of a spectral scan (test No. 359). Minima are due to variations in spectral sensitivity of film.

In order to obtain the radiance of the area observed on the plume, the film was calibrated in terms of the relative exposure produced by a secondary standard of spectral radiance calibrated against a National Bureau of Standards spectral radiance standard. The ribbon filament of the secondary standard was imaged on the entrance aperture of the spectrograph. Separate calibration exposures were made for each of the combination of filters used for the data exposures. Since the ratios of relative exposures of flame and standard were used in the data reduction process, the transmittances of the optical elements cancelled when the same elements were used in obtaining the relative exposures for both sources.

Values of spectral radiance of the flame were obtained at 200A intervals from 4000 to 6800A and are plotted in Fig. 6 for four range tests. From these data the instantaneous color temperature of the flame was estimated by the method, used by Curcio and Sanderson (2), which employs a form of Wien's equation. In this relationship the temperature is inversely proportional to the slope of a straight-line plot of log $N_\lambda \lambda^5$ vs $1/\lambda$, where N_λ is the spectral radiance of the flame and λ is the wavelength in cm. Figure 7 shows such

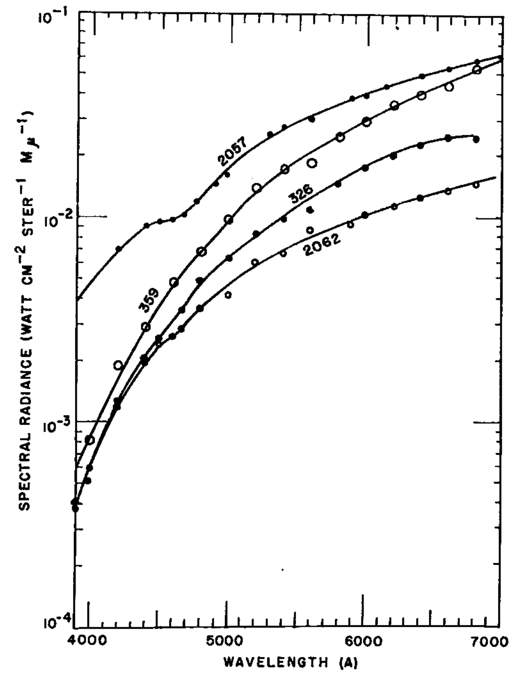


Fig. 6 - Instantaneous spectral radiance vs wavelength obtained with streak spectrograph for four range tests

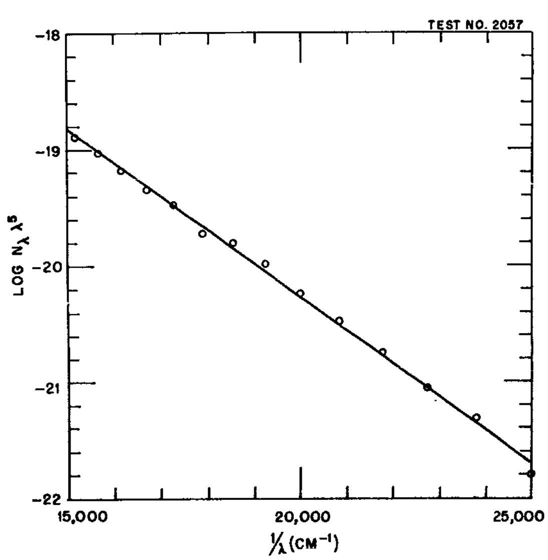


Fig. 7 - Typical plot of spectral data used to obtain color temperature, which is inversely proportional to slope of most appropriate straight line through data points. The spectral radiance of the flame at a given wavelength λ is N_λ (see Fig. 6).

Table 1
Average Radiant Emittance Values and Temperatures Calculated for Range Test Observations of Second-Stage Polaris Rocket Motor

Range Test No.	Average Radiant Emittance*		Temperature (°K) Calculated from	
	(w-cm^{-2})	(°K)†	Time-Resolved Spectra	Time-Integrated Spectra
326	40	1640	2325 (±49)‡	2380 (±80)
359	45	1680	2770 (±50)	
2052	37	1590		
2057	42	1650	2120 (±36)	
2062	52	1740	2530 (±57)	3540 (±58)

*The average emittance values were derived from radiance measurements, averaged over three-quarters of the total burning time, and the assumption that the source was a lambert radiator.
†These equivalent temperatures assume an emissivity of unity (blackbody).
‡Values in parentheses indicate 65-percent limits of error.

a plot of the data for test No. 2057. The slope of the most appropriate line was calculated by the least-squares method and, in addition, the standard deviation of the slope was calculated. The resulting temperatures and corresponding 65-percent limits of error are listed in Table 1.

The color temperatures obtained at 10-sec intervals on test No. 2057 are plotted as a function of time in Fig. 8 (solid curve). The dashed curves show the 65-percent limits of error.

The time-resolved spectra show no evidence of line or band structure whereas the time-integrated spectra showed some weak structure. The spectral irregularities in density which are noticed in Figs. 4 and 5 are due to variations in film sensitivity. Also evident in Fig. 4 are variations of density with time; these variations appear to be a modulation of the flame intensity at the observed spot. The "frequency" of this modulation was estimated by counting the number of light streaks per unit time at several different time locations on the film during the total burning time. The approximate frequency was 190 cps at a film speed of 3.10 in./sec, 400 cps on the film run at 8.25 in./sec, and 500 cps at 9.75 ft/sec. The low frequency obtained when the lowest film speed was used may have been due to the limited frequency resolution capability of the system, namely, 258 cps maximum, the equivalent of one pinhole diameter on the film. In Fig. 4 it can be seen from the irregular spacing of the streaks that more than one frequency appeared to be present. Similar results were obtained by Cumings, Guinard, and Boyd (3) who made a frequency analysis of the light intensity modulation of liquid-fuel rocket flames. For various fuel/liquid-oxygen mixtures the maximum frequency nearly always occurred between 400 and 700 cps.

The high-speed streak camera was operated on the last two tests in an effort to learn more about this modulation. The films showed small random intensity fluctuations when first started but no detectable modulation when the camera was running at its final speed

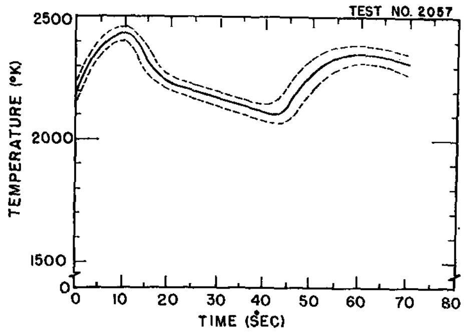


Fig. 8 - Instantaneous color temperature (solid curve) as a function of time measured at 10-sec intervals on test No. 2057. The dashed curves indicate the 65-percent limits of error.

of 38 ft/sec. The modulation may have failed to appear on the film because of the high film speed and because of overexposure. To determine if the spectral modulation were a mechanical effect due to vibration, accelerometers were attached to the spectrograph on the final test. They indicated a maximum acceleration of 1.6g in the lateral direction and negligible vibration in the other two dimensions. Since only vibrations in the vertical plane would cause the apparent modulation, it is believed that vibration was not the cause but that the flame itself possessed the modulation.

Time-Integrated Spectra

Two satisfactory exposures were made of time-integrated spectra of Polaris second-stage rocket motor plumes. The analysis of the exposed plates followed the same procedure used for the 70-mm film, including the methods of obtaining H&D curves and of calibrating the standard lamp with the filter and step wedge used for the data exposures.

The time-integrated spectrum resulting from test No. 326 (Fig. 9) shows predominantly a continuum, with very faint Al and Na lines and a few of the AlO bands. The only filter present in the optical path was the step wedge. The color temperature of 2380°K calculated from these data is listed for comparison in Table 1. The relatively large limit of error shown in the table is an indication of the spread of the data points about a straight line.

In the time-integrated spectrum of test No. 2062 (Fig. 10) the line and band structure appears somewhat stronger. This may be due to the relatively weak continuum exposure, which would mask less of the structure. A silver-film transmission filter was used to reduce the relative exposure in the red. The color temperature (3540°K) produced by these data was much higher than those produced by the other two systems. Although the thermopile data indicate that this motor produced the highest radiant emittance of any observed, it does not indicate such a great disparity from the others.

Emissivity of the Flames

An indication of the emissivity of a flame is given by comparing the equivalent blackbody temperatures obtained from the radiant emittance measurement to the color temperatures obtained from the spectral radiance measurements. Taking the ratio of blackbody radiant emittances for the given temperatures, the emissivity values obtained varied between 0.14 and 0.37 for three of the four tests on which comparisons could be made. The fourth test produced an emissivity of 0.59. It should be noted, however, that any attenuation of

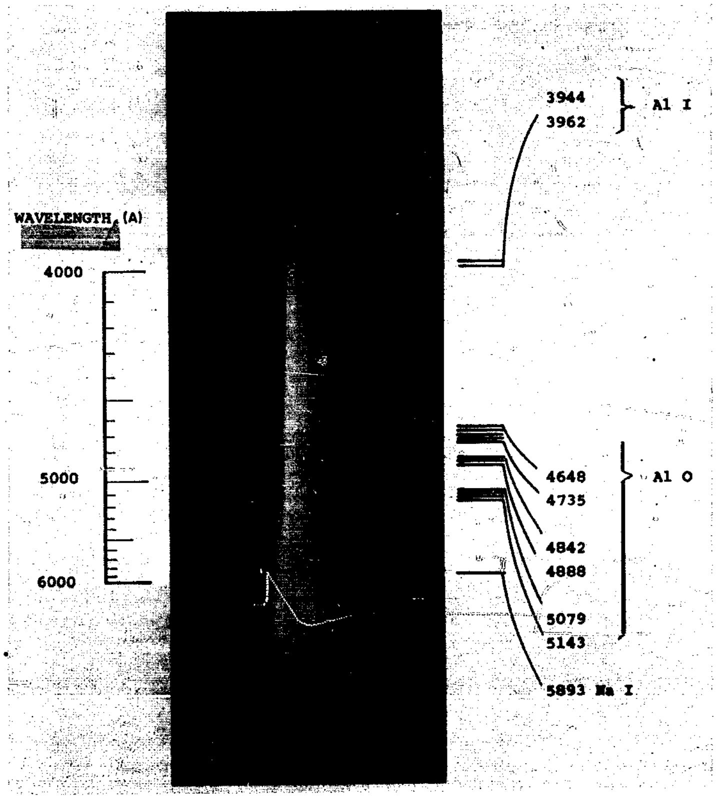


Fig. 9 - Time-integrated spectrum of test No. 326. The faintly visible mercury wavelength calibration appears to left of flame spectrum.

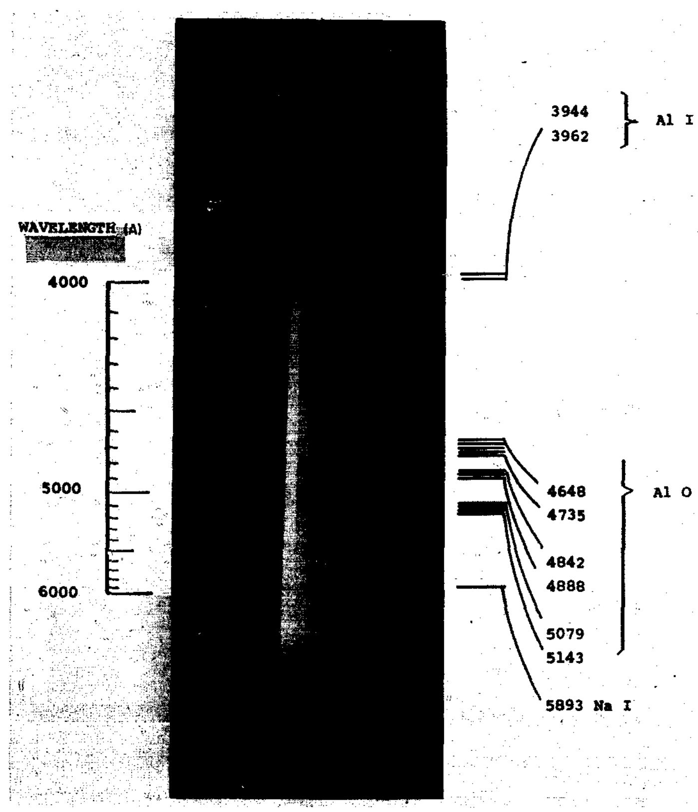


Fig. 10 - Time-integrated spectrum of test No. 2062

the light emitted by the flame, as for example the attenuation produced by the smoke which is copiously generated by these flames, may produce an effect identical with that here ascribed to an emissivity less than one. No great confidence should therefore be placed in these emissivity values.

SUMMARY

The radiant energy emitted by Polaris second-stage motor plumes was obtained from three different measurements, namely, radiant emittance as a function of time, spectral radiance as a function of time, and spectral radiance integrated over the total burning time. All instruments used to make the measurements were aimed at the same point on the plume axis, but the sizes of their fields of view differed. The flame spectrum was predominantly a continuum on which were superimposed weak lines of aluminum and sodium and weak bands of AlO. No zones of absorption were noted in the region from 3600 to 6800A.

Instantaneous color temperatures derived from the time-resolved spectra at positions on the spectra records corresponding to a burning time of +40 sec vary from 2120 to 2770°K, the mean temperature being about 2430°K. Also, for one test the instantaneous color temperatures were derived at 10-sec intervals from +0.05 to +70 sec, giving a total of eight temperatures which ranged from 2120 to 2435°K. The higher temperature corresponds to a radiance 1.8 times that at the lower temperature.

On a time basis the radiant emittance measurements lie between the time-resolved spectra and the time-integrated spectra because of the 6-sec time constant of the detector. The equivalent blackbody temperatures derived from radiant emittance values do not include a correction for the emissivity of the flames. These two factors make comparison of these temperatures with those obtained by the other methods of little value other than to determine an approximate emissivity for the flame. The mean value of emissivity determined from three such comparisons was 0.25.

Of the two satisfactory time-integrated spectra, one (test No. 326), which was overexposed, yielded a temperature comparable to the instantaneous temperature at +40 sec. The other spectrogram (test No. 2062) possessed a good latitude of exposure but yielded a temperature much higher than that indicated by the time-resolved spectrum at +40 sec. No explanation can be found for this discrepancy.

The modulation of the flame noted in the high-speed spectra appears to be genuine and has the same predominant frequency as found by other workers who have studied liquid propellant flames.

ACKNOWLEDGMENTS

The author gratefully acknowledges the cooperation and assistance of the test directors and range personnel of the Allegany Ballistics Laboratory, Cumberland, Md. He also wishes to thank A. G. Rockman for his assistance in the installation of equipment and in making the measurements, C. V. Acton for the photographic processing, J. A. Curcio for his helpful discussions, and Dr. L. F. Drummeter for helpful criticism of the manuscript.

REFERENCES

1. Harrington, F. D., and Knestrick, G. L., "Color Temperature and Spectral Profile of Some Propellant Grains," NRL Report 6066, Mar. 1964

2. Curcio, J. A., and Sanderson, J. A., "Further Investigations of the Radiation from Rocket Motor Flames," NRL Report N-3327, July 1948

3. Cumings, R. G., Guinard, N. W., and Boyd, F. E., "Rocket Motor Flame Light Intensity Versus Time," NRL Report 4959, July 1957

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Naval Research Laboratory. Report 6117 [CONF.] TEMPERATURE AND SPECTRAL PROFILE OF FULL-SCALE PROPELLANT GRAINS [Unclassified Title], by G. L. Knestrick. 15 pp. and figs., July 22, 1964.

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CONFIDENTIAL [Grp. 3]

1. Fleet ballistic missiles – Exhaust gases – Spectrographic analysis
2. Rocket motors – Exhaust gases – Temperatures

I. Polaris

II. Knestrick, G. L.

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AD0352827 (NRL-6117)	Declassified with no restrictions 1/25/1996
AD0361630 (NRL-6247)	Declassified with no restrictions 1/7/1997
AD0377010 (NRL-6476)	Declassified with no restrictions 1/29/1997
AD0377011 (NRL-6485)	Declassified with no restrictions 1/29/1997
AD0377242 (NRL-6479)	Declassified with no restrictions 1/29/1997
AD0379058 (NRL-6508)	Declassified with no restrictions 1/29/1997
AD0379893 (NRL-6507)	Declassified with no restrictions 1/29/1997
AD0346383 (NRL-6015)	Declassified with no restrictions 1/29/1997
AD0349268 (NRL-6079)	Declassified with no restrictions 1/29/1997
AD0355651 (NRL-6198)	Declassified with no restrictions 1/29/1997
AD0368068 (NRL-6371)	Declassified with no restrictions 1/29/1997

Thank you,

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